Wet Scavenging of Soluble Trace Gases in Deep Convective Clouds: A Comparison of SEAC4RS and DC3 Sampling Strategies

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Instrument Teams: DACOM, ESRL, CAMS, DFGAS, P-CIMS, S-CIMS, GT-CIMS, VCSEL, DLH, CDP, 2D-S

Atmospheric and Oceanic Sciences
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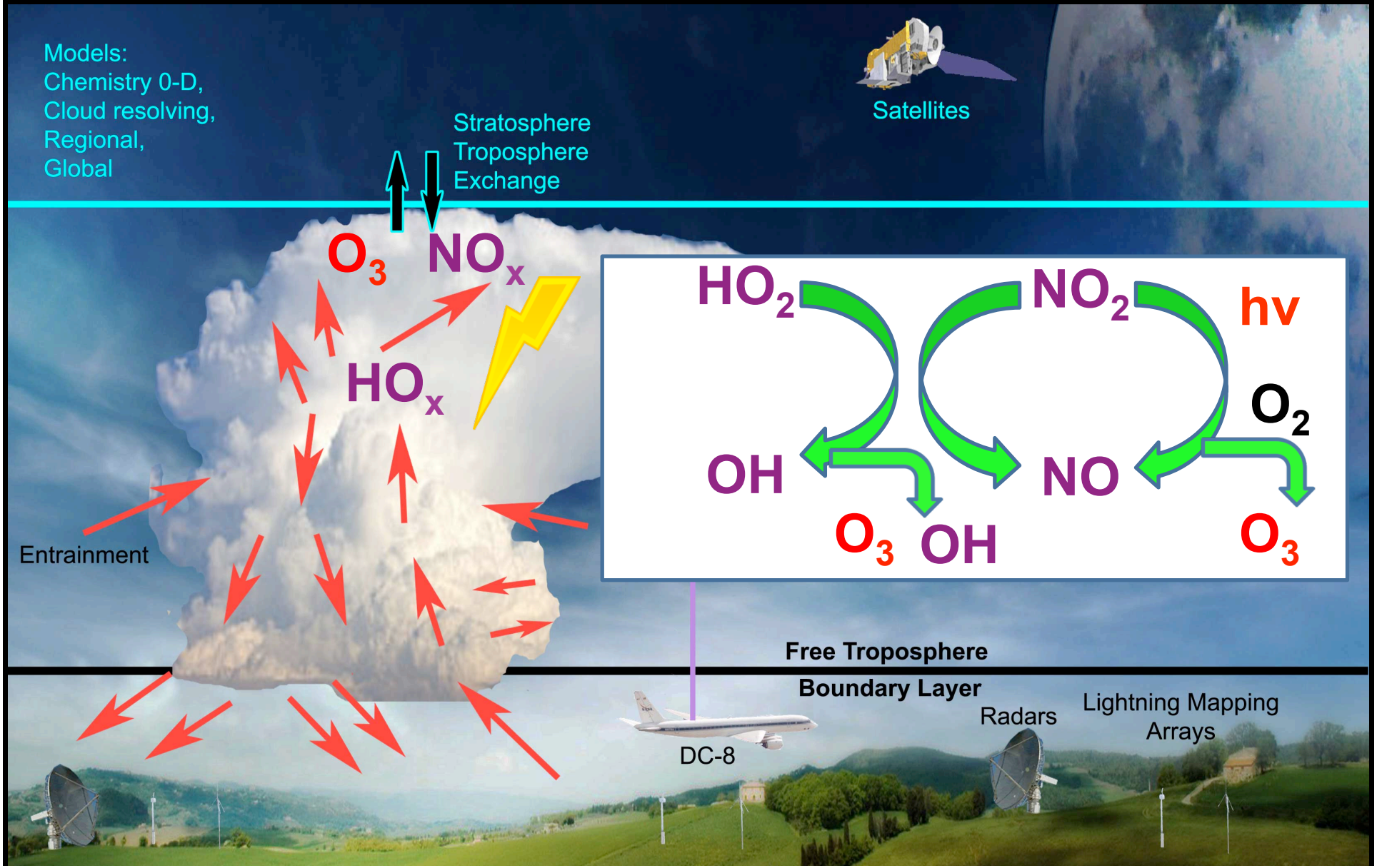
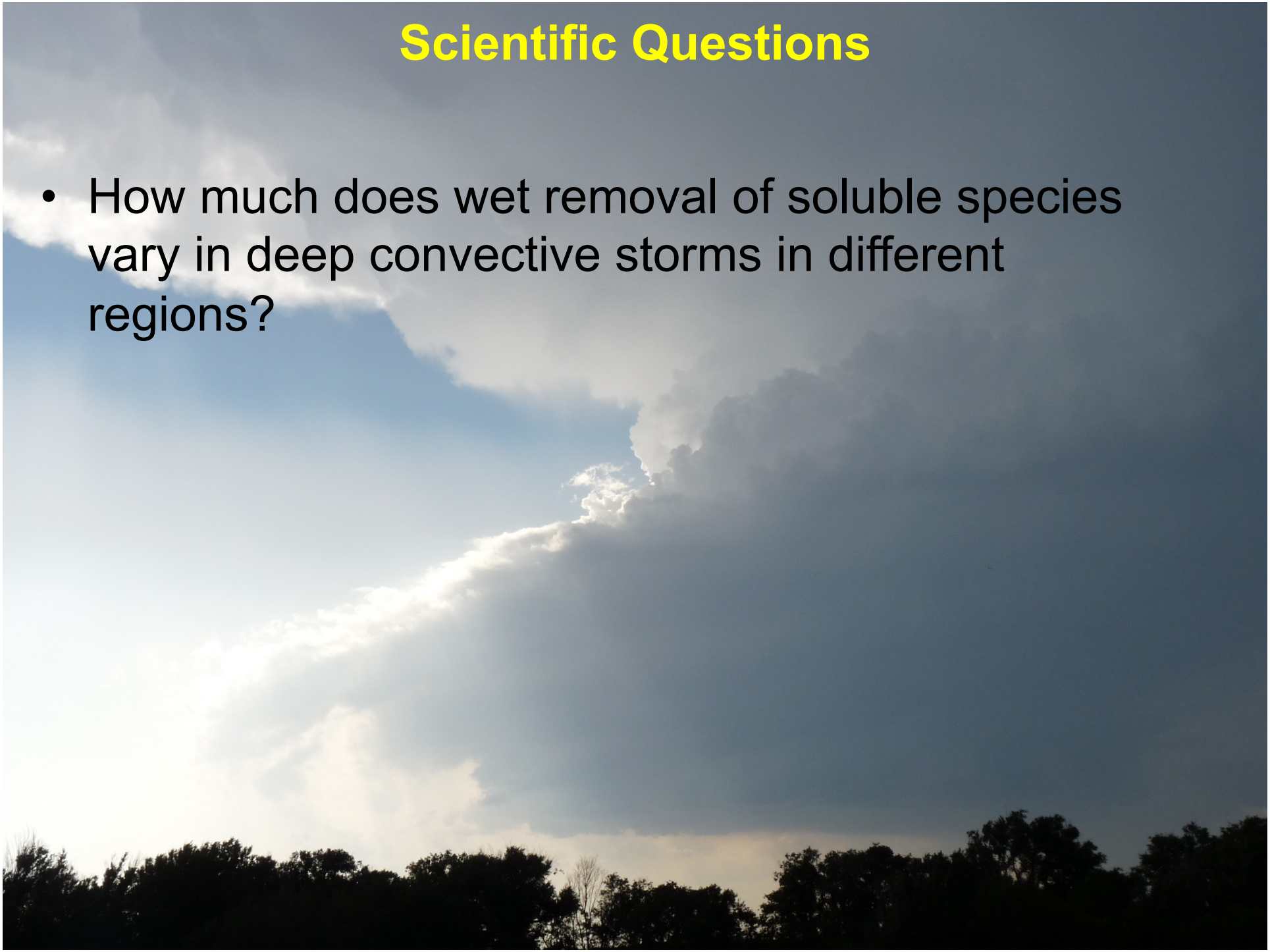
Laboratory for Atmospheric and Space Physics
University of Colorado **Boulder**

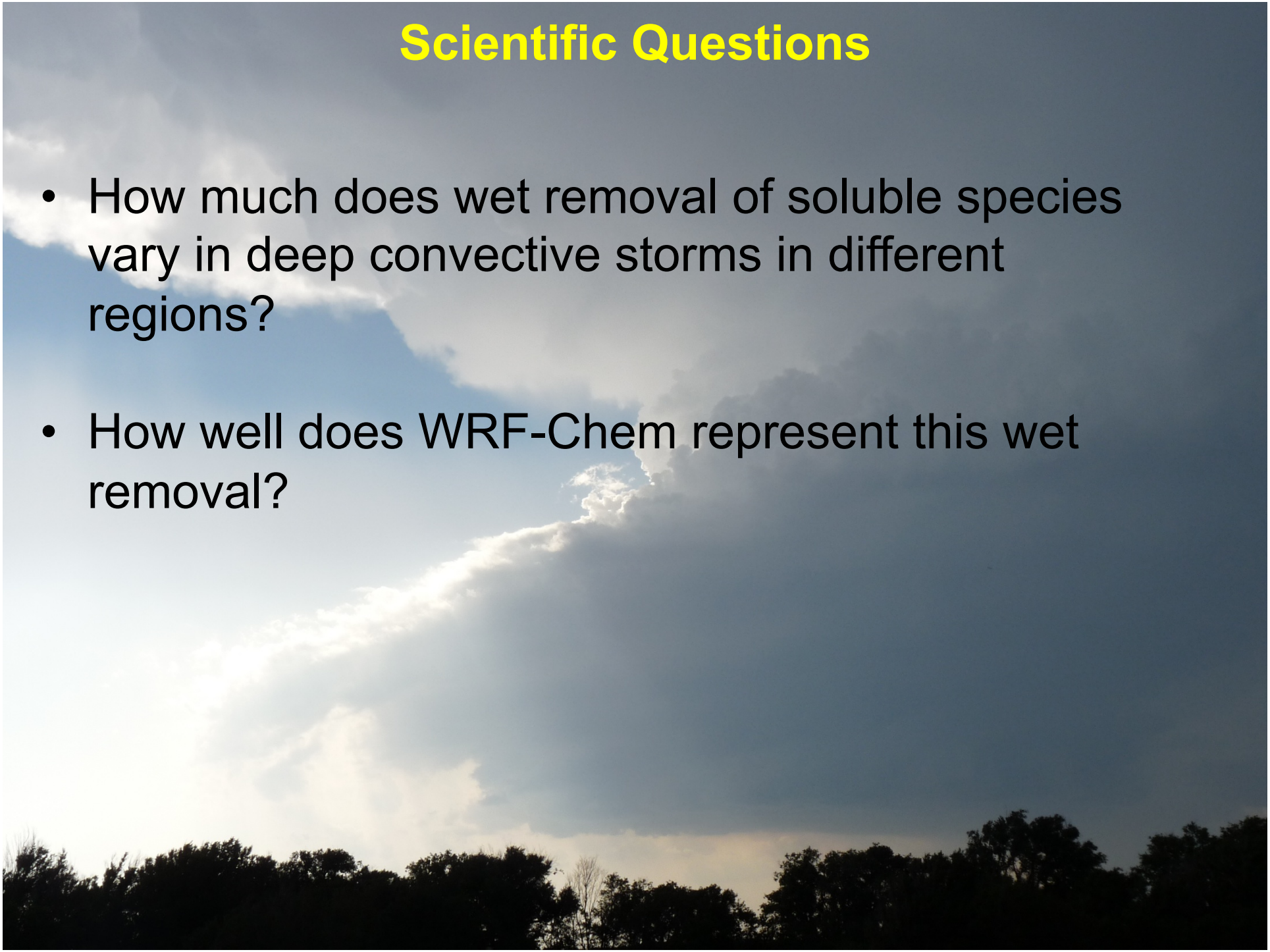
O_3 formation in UT controlled by HO_x and NO_x; many HO_x precursors are soluble





Scientific Questions

- How much does wet removal of soluble species vary in deep convective storms in different regions?



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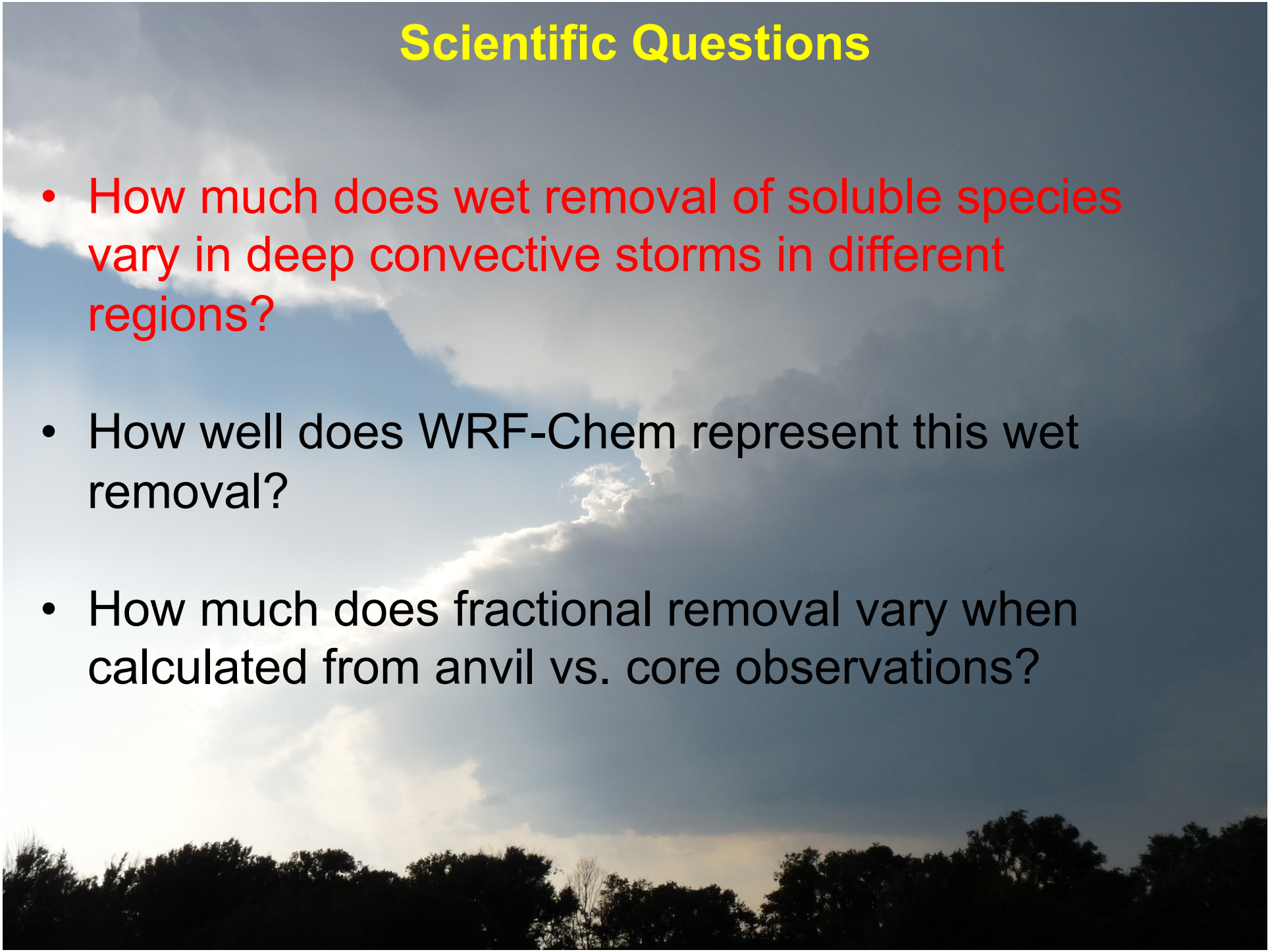

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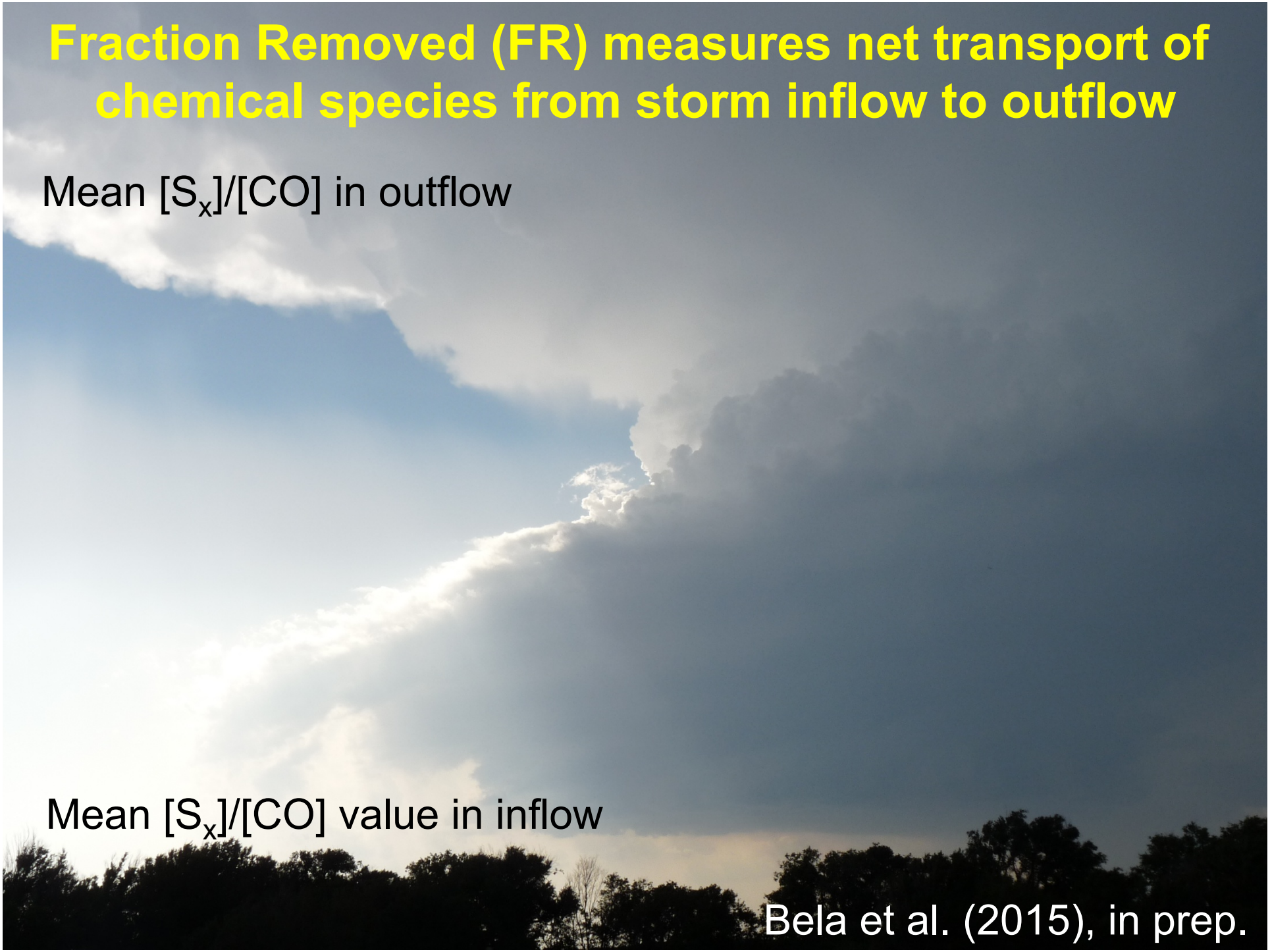
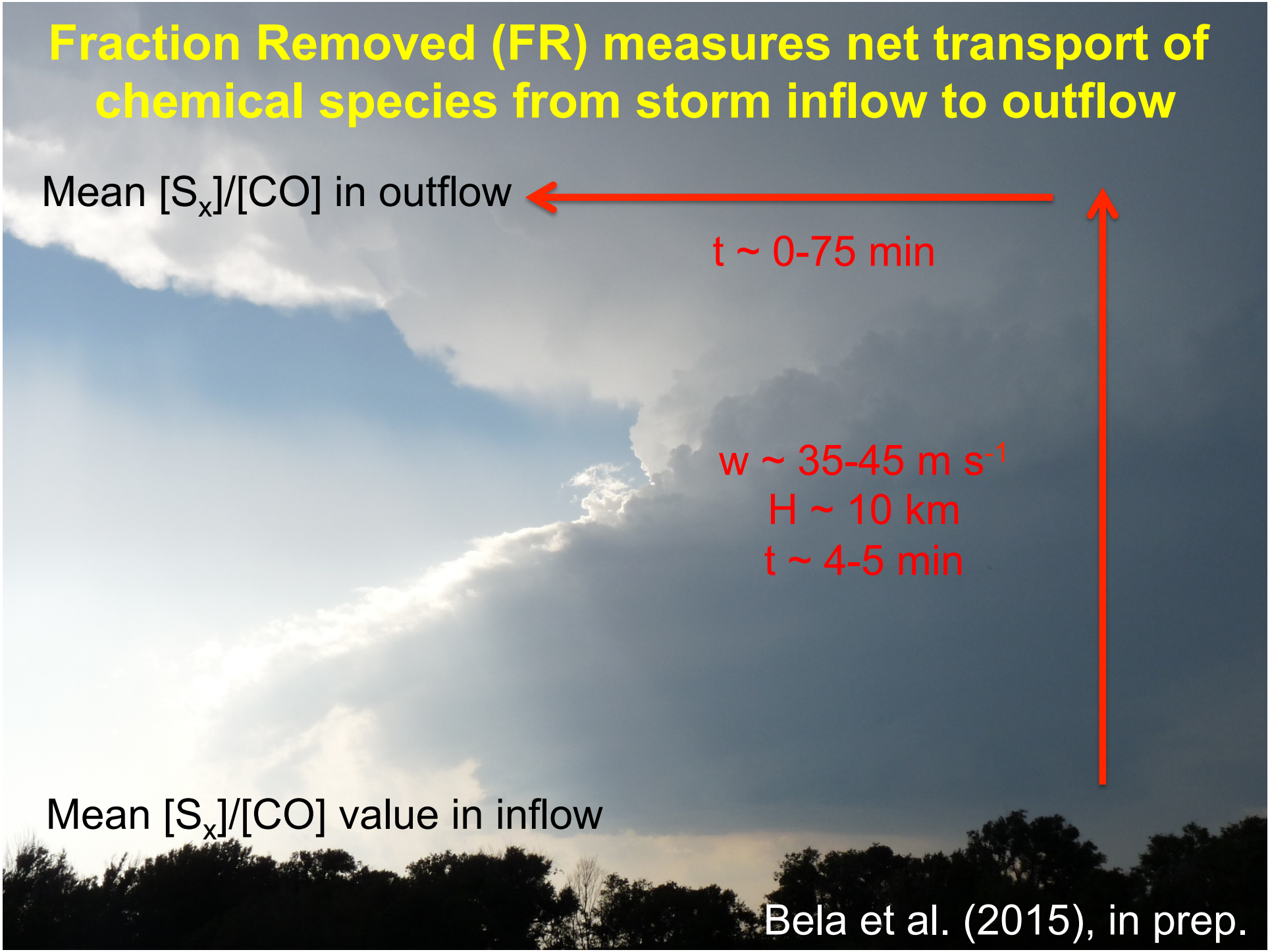
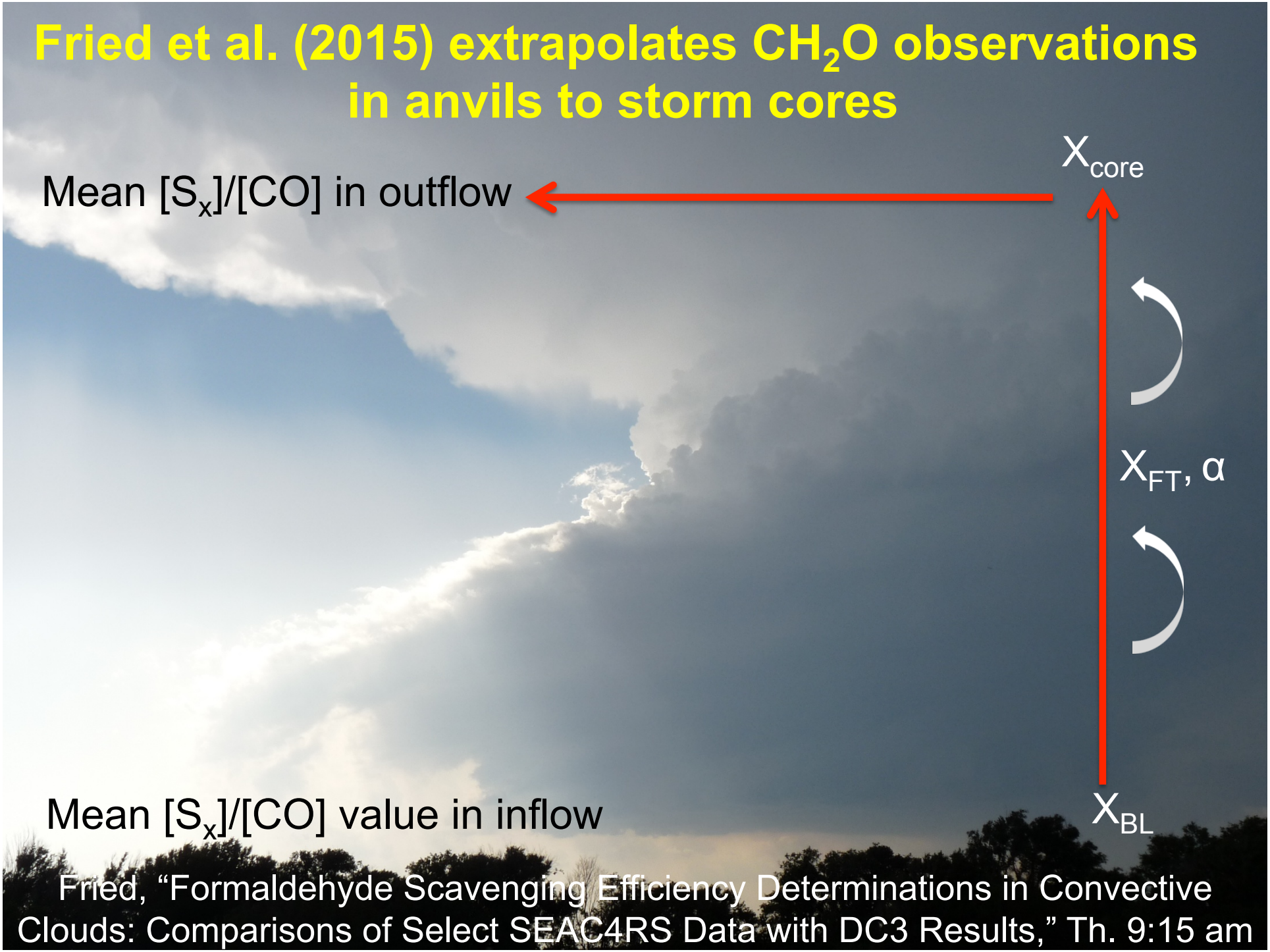

Fraction Removed (FR) measures net transport of chemical species from storm inflow to outflow
Mean [S_x]/[CO] in outflow
Mean [S_x]/[CO] value in inflow
Bela et al. (2015), in prep.

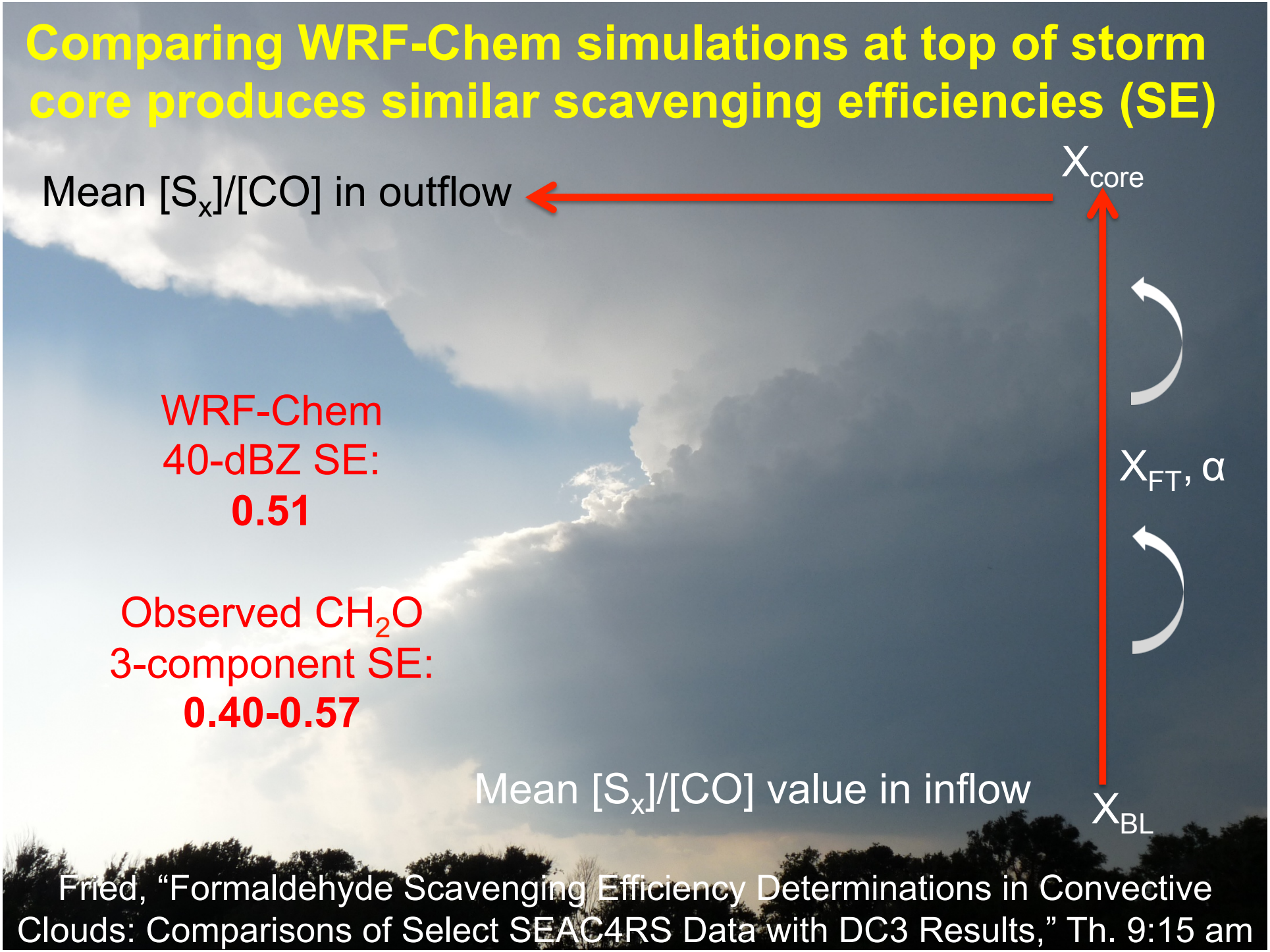

Fraction Removed (FR) measures net transport of chemical species from storm inflow to outflow
Mean [S_x]/[CO] in outflow
t ~ 0-75 min
w ~ 35-45 m s^{-1}
H ~ 10 km
t ~ 4-5 min
Mean [S_x]/[CO] value in inflow
Bela et al. (2015), in prep.

Fried et al. (2015) extrapolates CH_2O observations in anvils to storm cores



Fried, "Formaldehyde Scavenging Efficiency Determinations in Convective Clouds: Comparisons of Select SEAC4RS Data with DC3 Results," Th. 9:15 am

Comparing WRF-Chem simulations at top of storm core produces similar scavenging efficiencies (SE)



WRF-Chem
40-dBZ SE:
0.51

Observed CH_2O
3-component SE:
0.40-0.57

Fried, "Formaldehyde Scavenging Efficiency Determinations in Convective Clouds: Comparisons of Select SEAC4RS Data with DC3 Results," Th. 9:15 am

Do fractions removed vary significantly among storms in different regions?

Bela et al. (2015), in prep.

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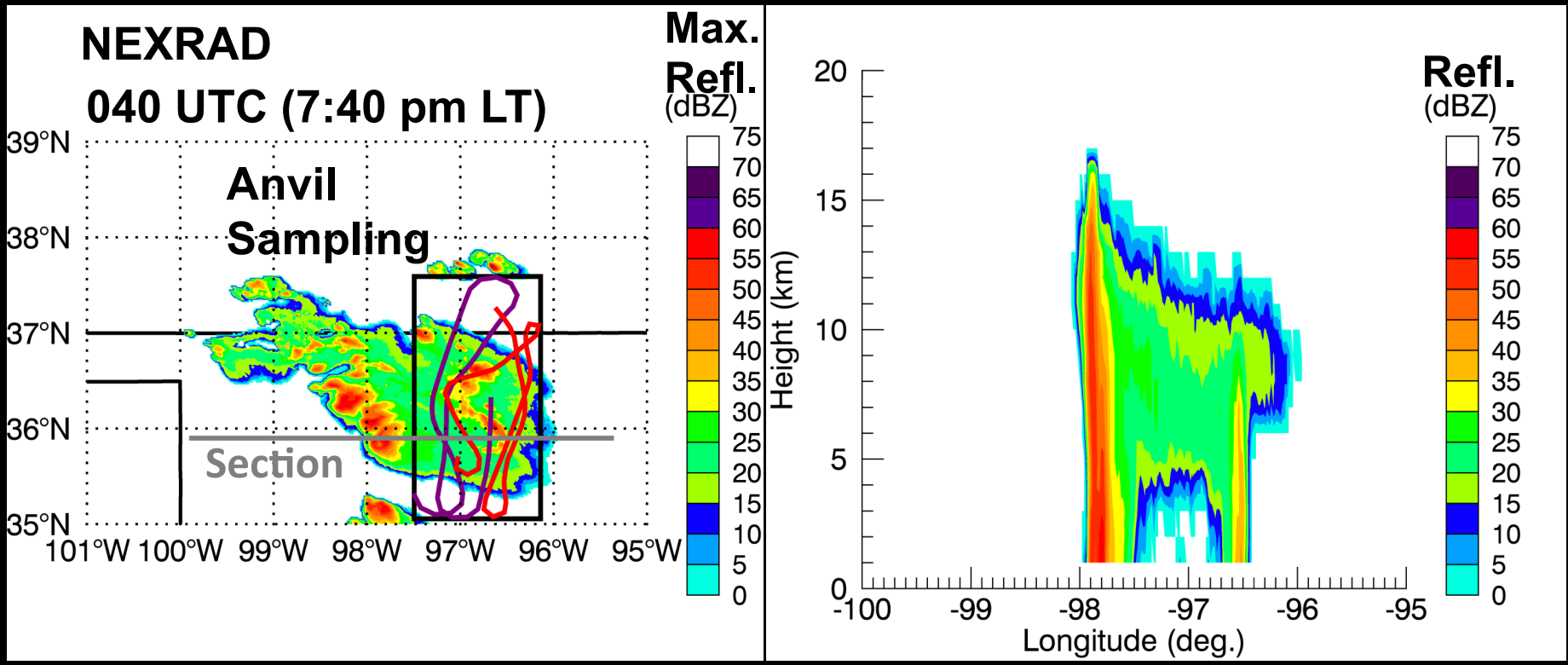
multi-cellular system, Oklahoma
May 29, 2012



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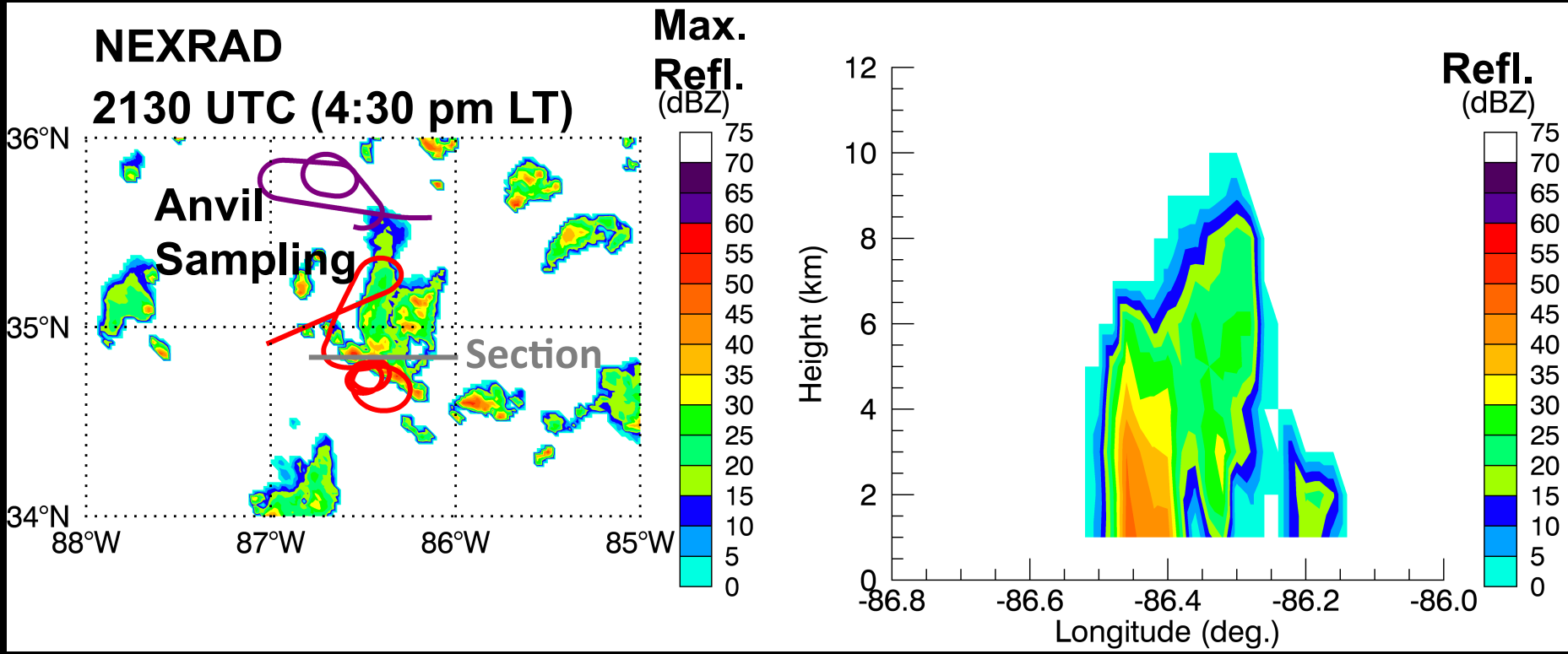
Do fractions removed vary significantly among storms in different regions?

Airmass storm, Alabama
May 21, 2012



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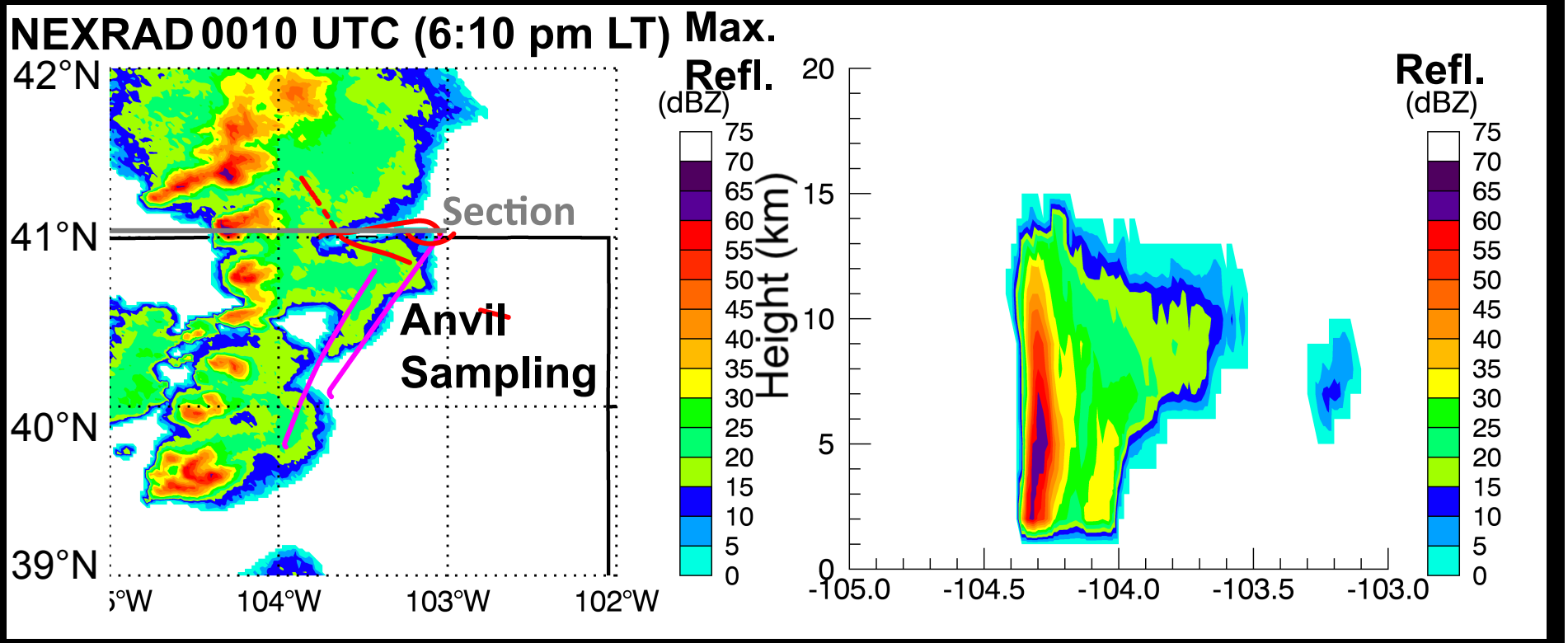
Do fractions removed vary significantly among storms in different regions?

Severe storm, Colorado
June 6, 2012



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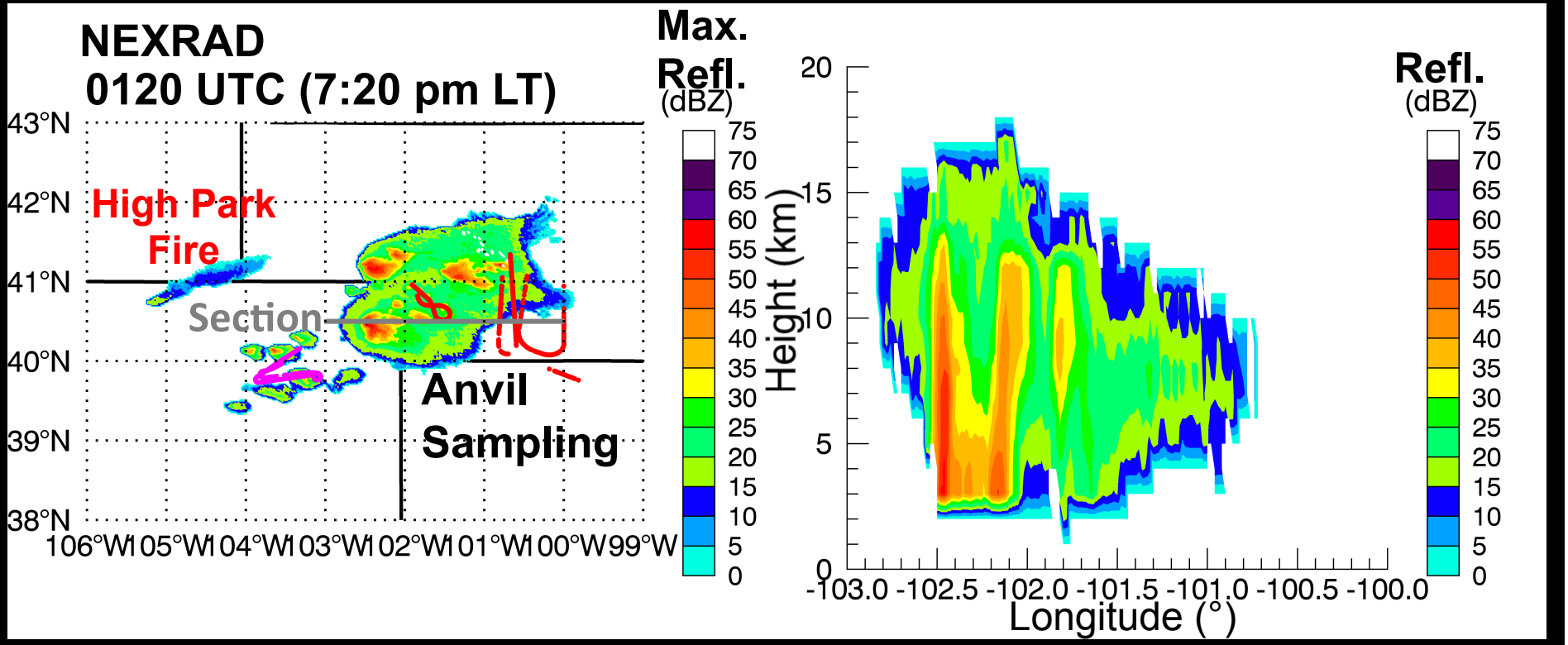
Do fractions removed vary significantly among storms in different regions?

Multi-cellular storm system with smoke ingestion, Colorado, June 22, 2012



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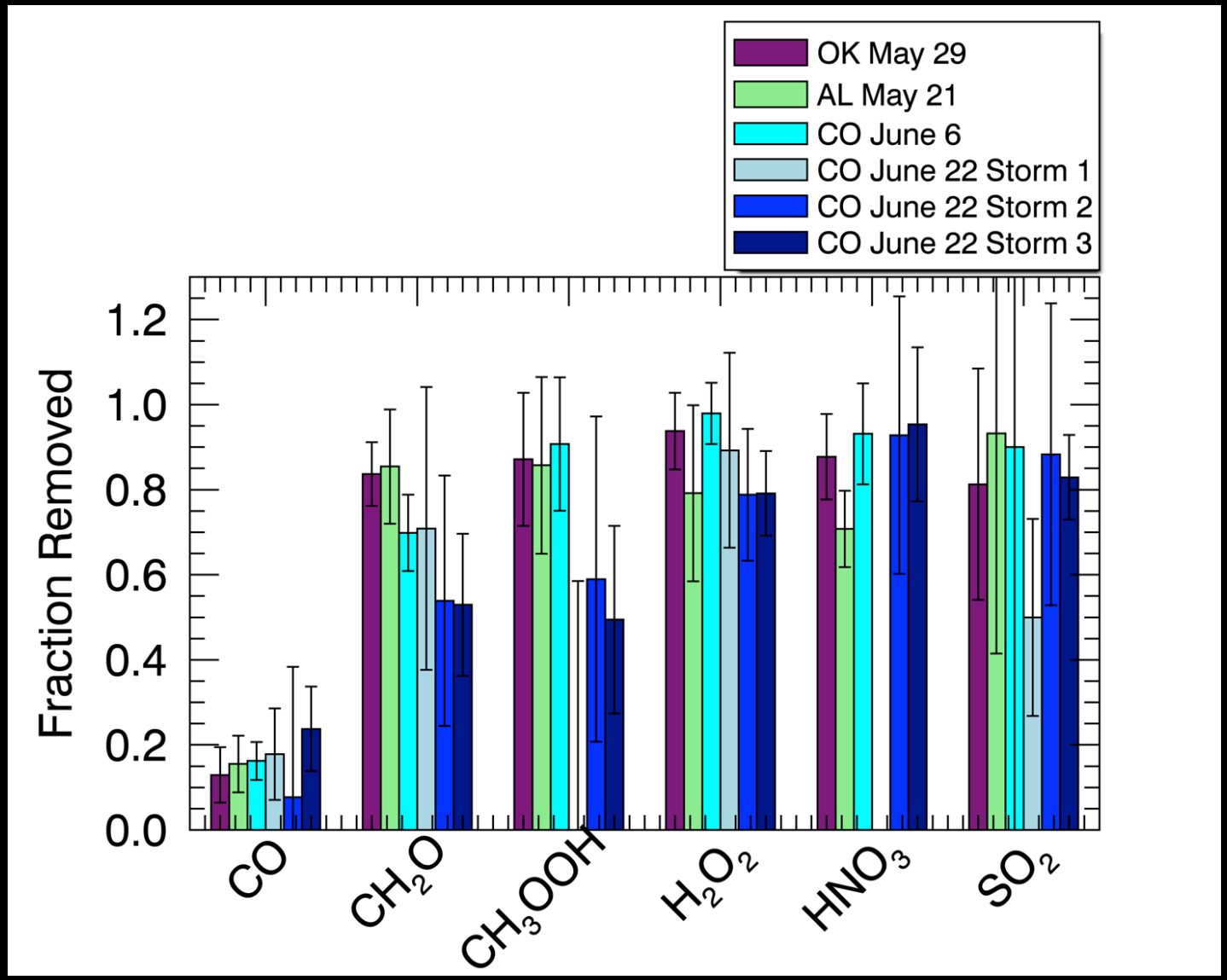

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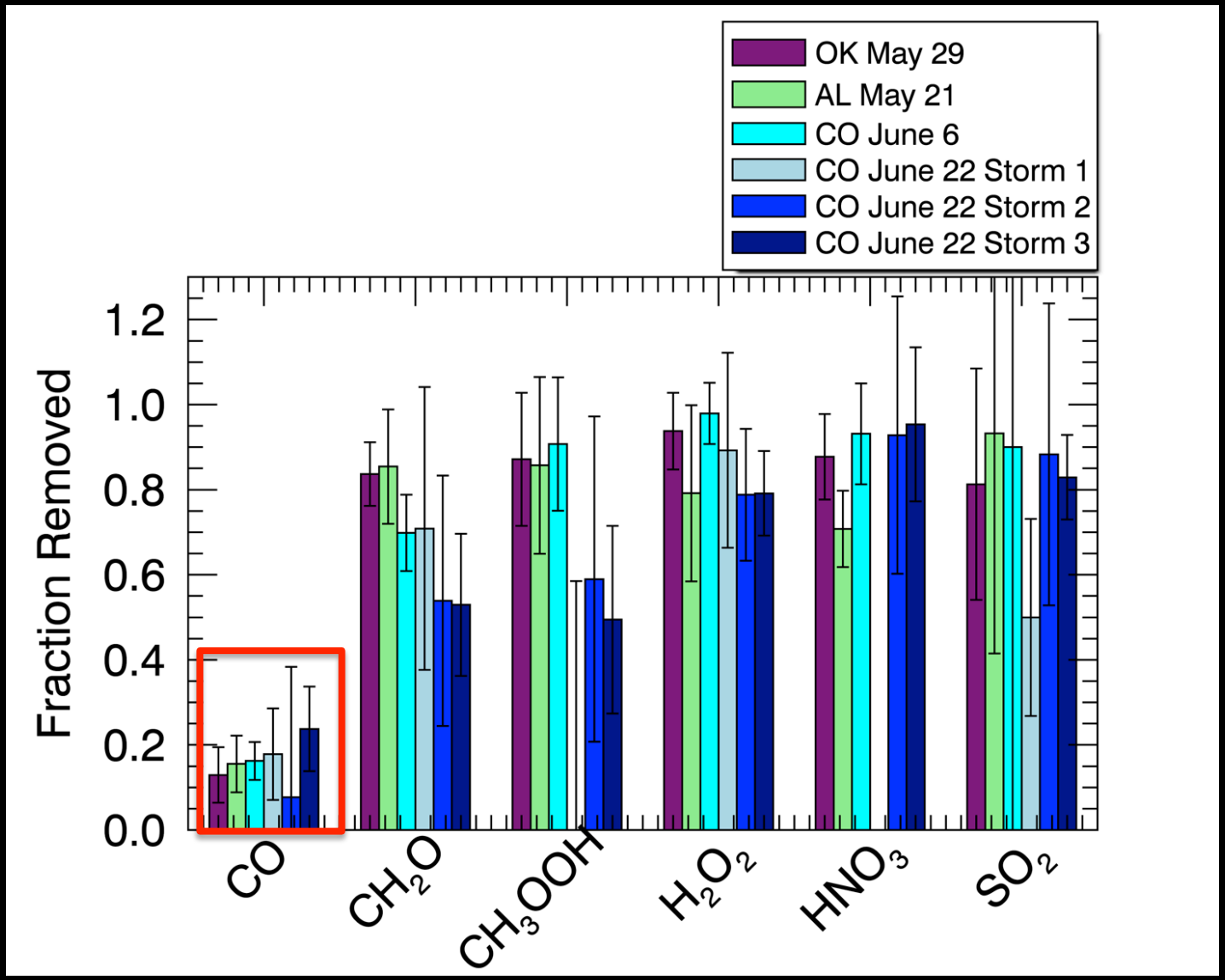
"Fraction removed" of CO is an indication of amount of entrainment



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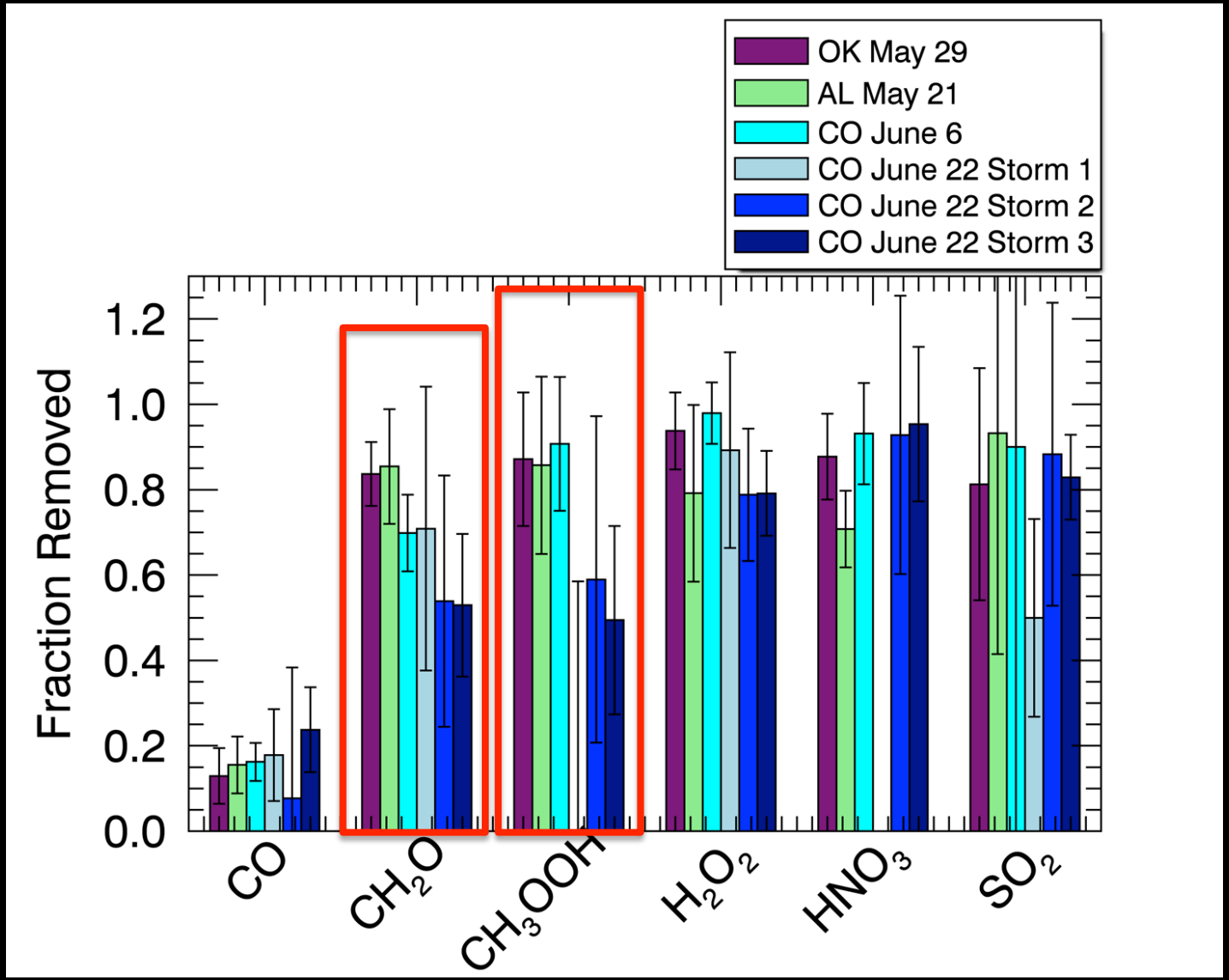
OK/AL storms remove more CH_2O and CH_3OOH than those in Colorado



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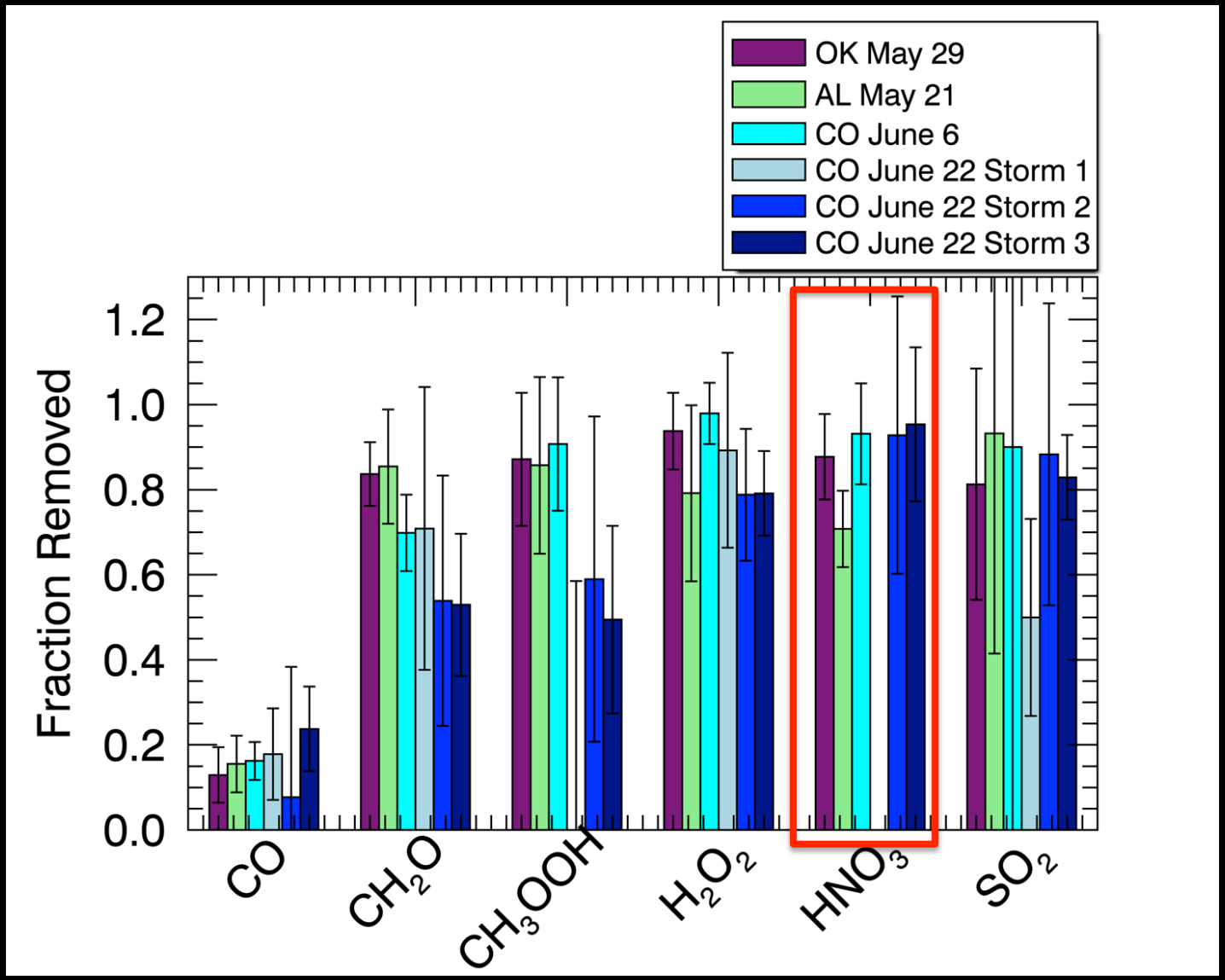
Colorado storm cases remove more HNO_3 than OK/AL storms



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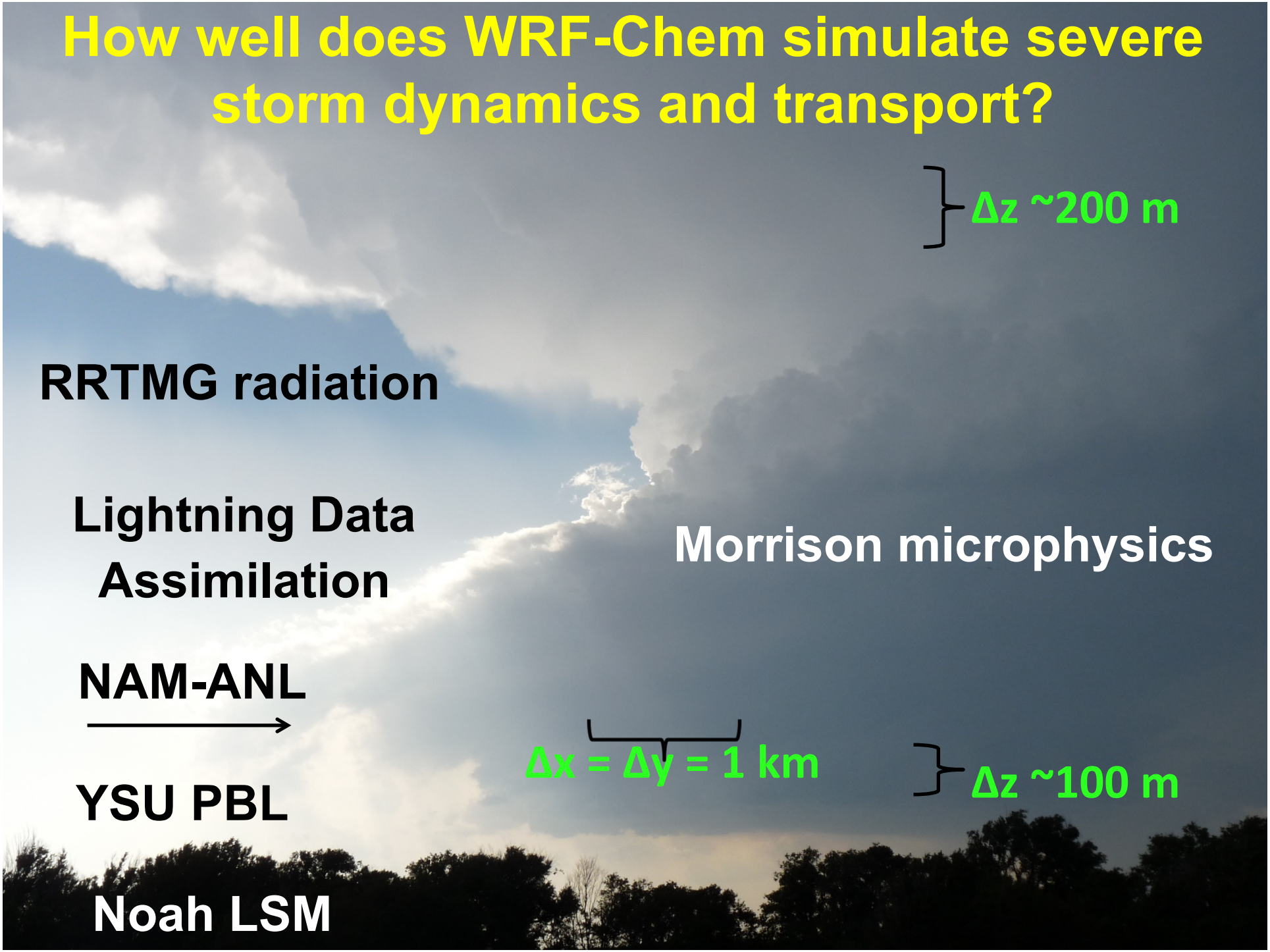
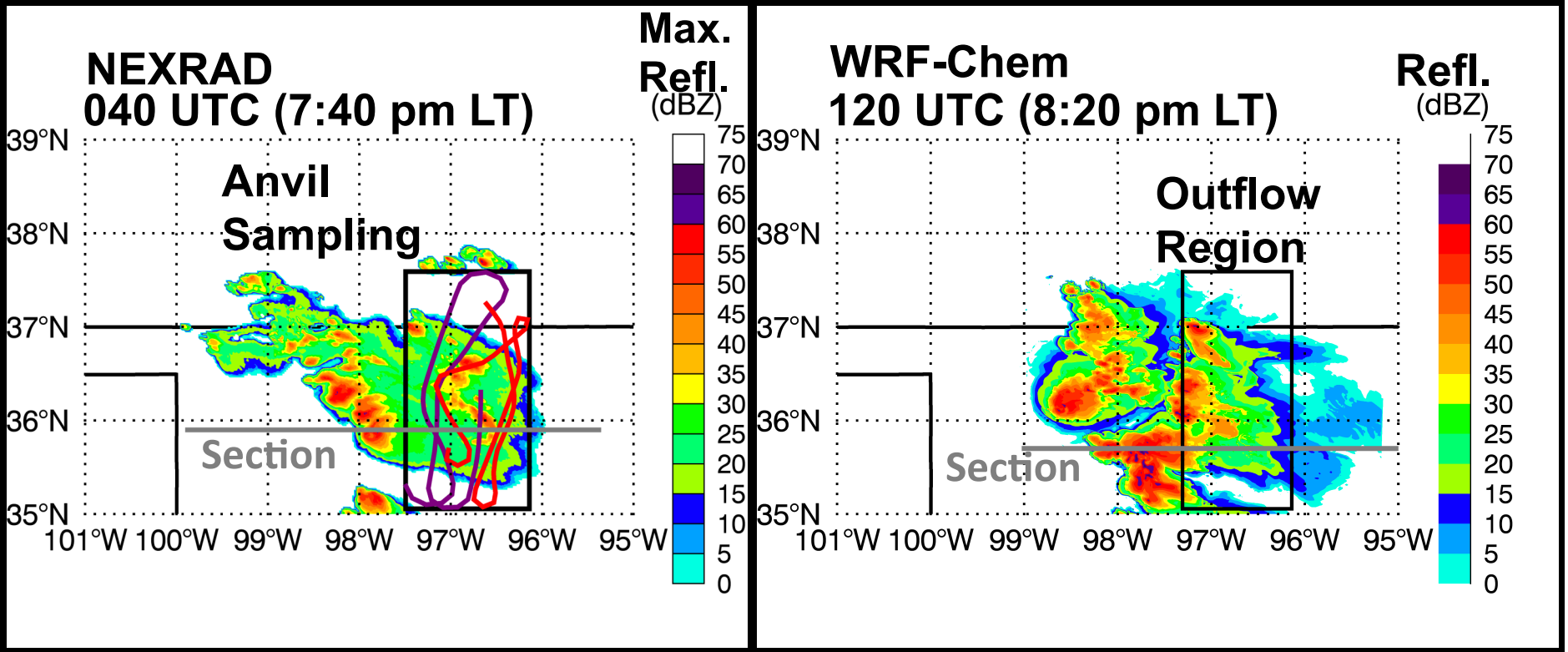

How well does WRF-Chem simulate severe storm dynamics and transport?
Δz ~200 m
RRTMG radiation
Lightning Data Assimilation
Morrison microphysics
NAM-ANL
Δx = Δy = 1 km
Δz ~100 m
YSU PBL
Noah LSM

WRF-Chem Simulates Location, Timing, Structure of May 29, 2012 Severe Storm in Oklahoma



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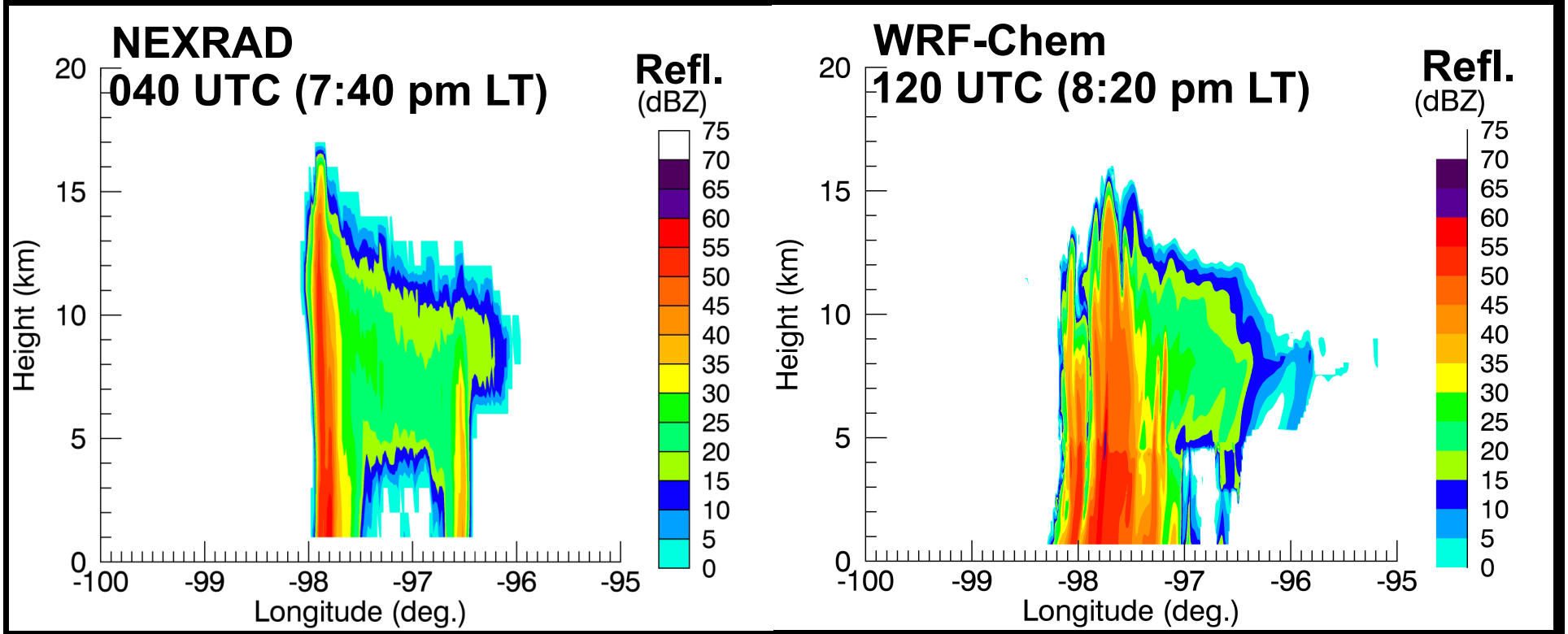

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How well does WRF-Chem simulate wet removal of soluble species?

PR1992/Decaria lightning NO_x

MOZART chemistry

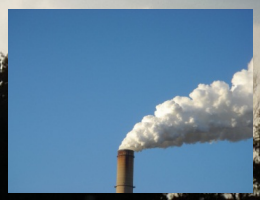
TUV photolysis

GOCART aerosol

Neu and Prather wet scavenging

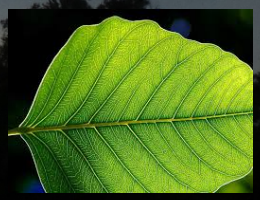
MOZART, DC-8 Obs.

NEI 2011

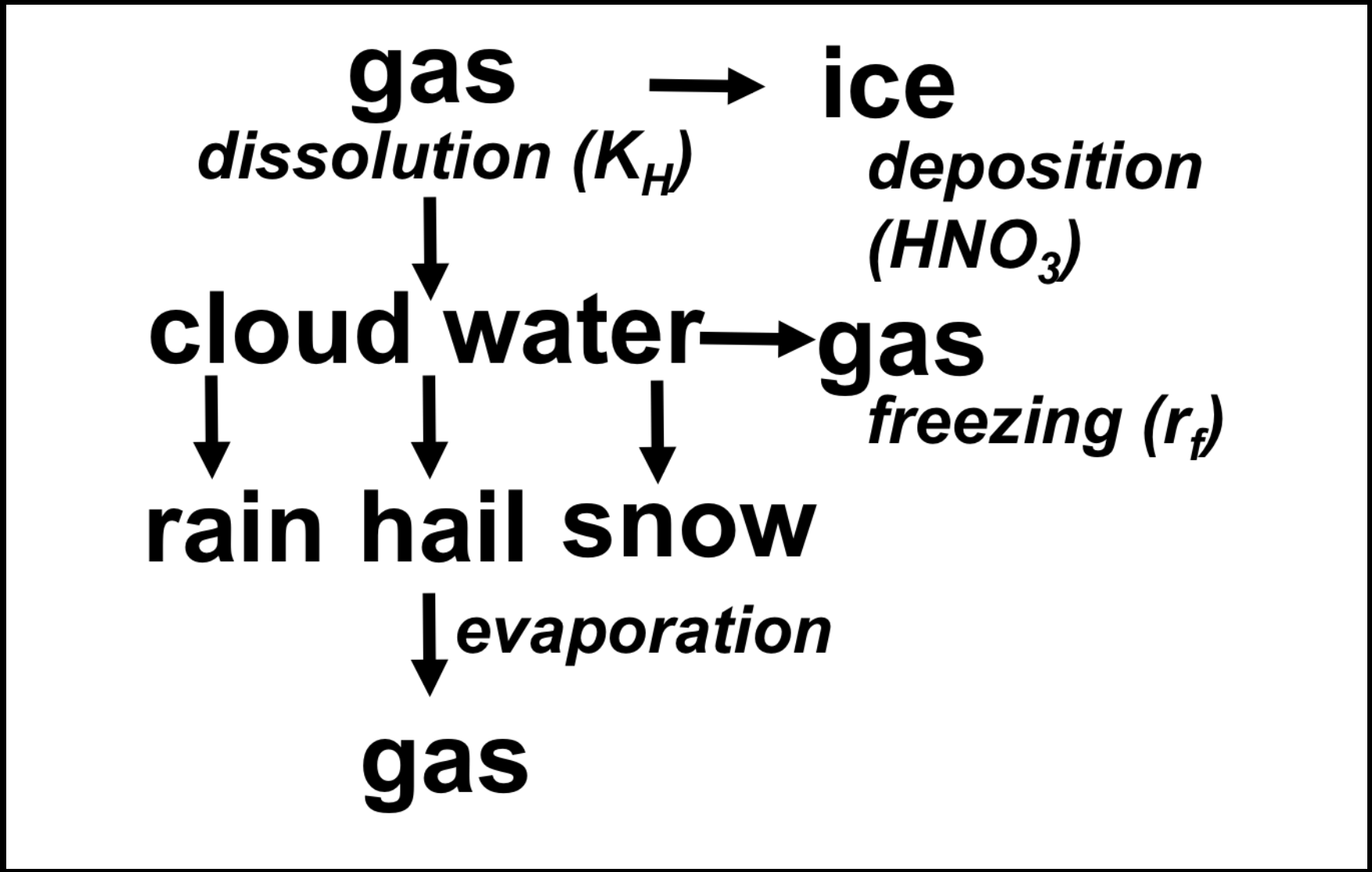


FINN

MEGAN v2.04



Neu and Prather wet scavenging does not track dissolved species



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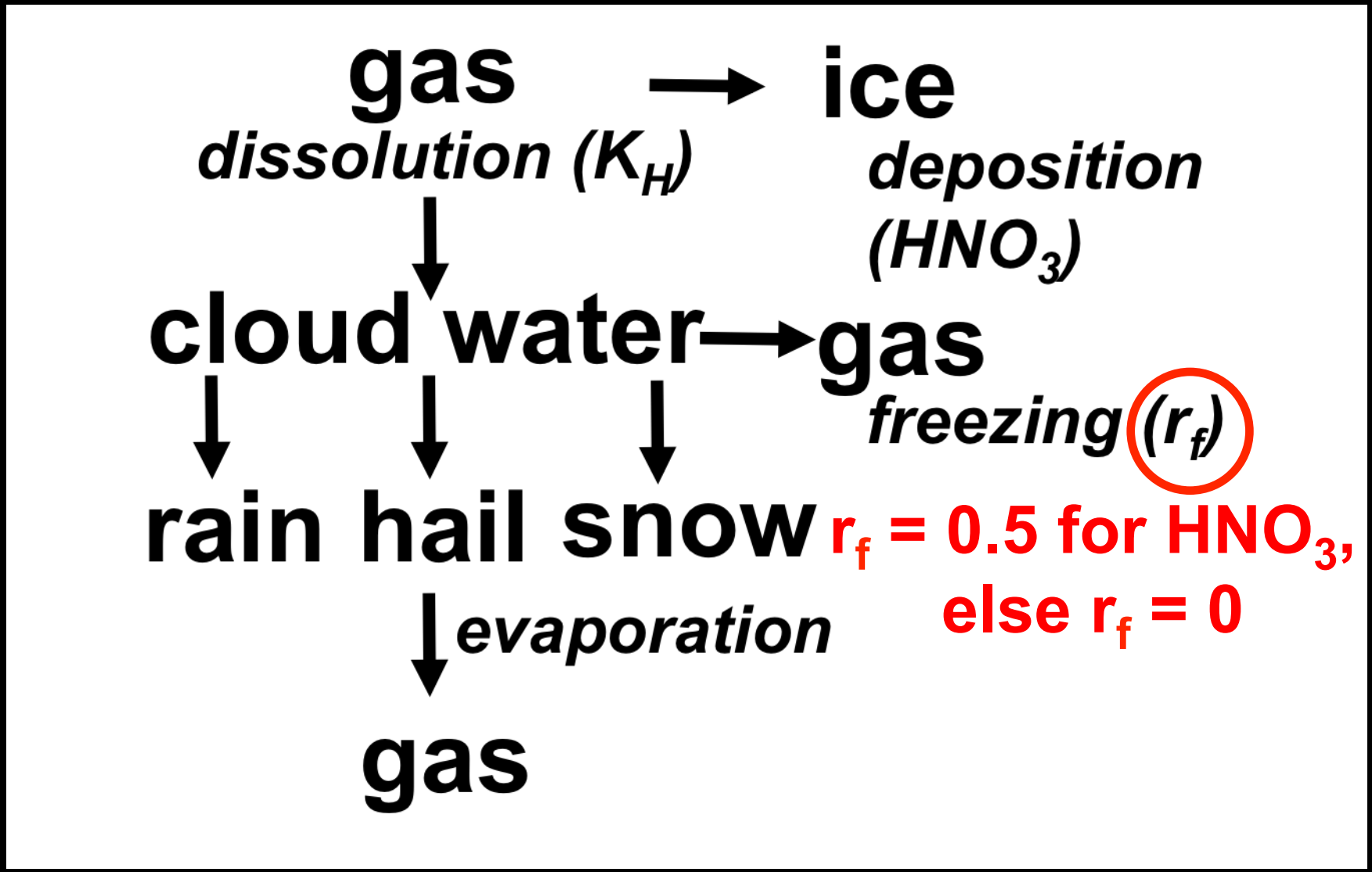

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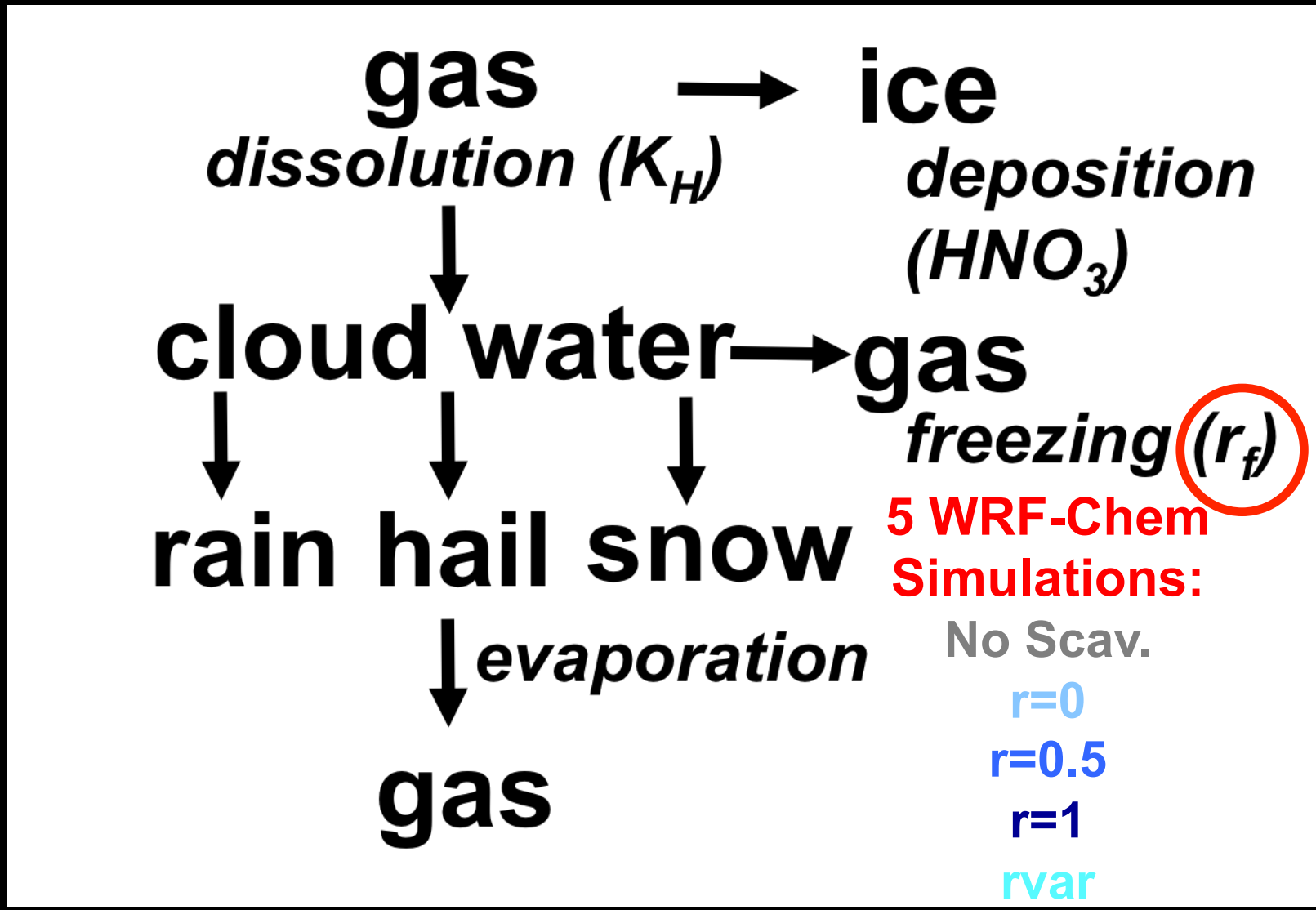

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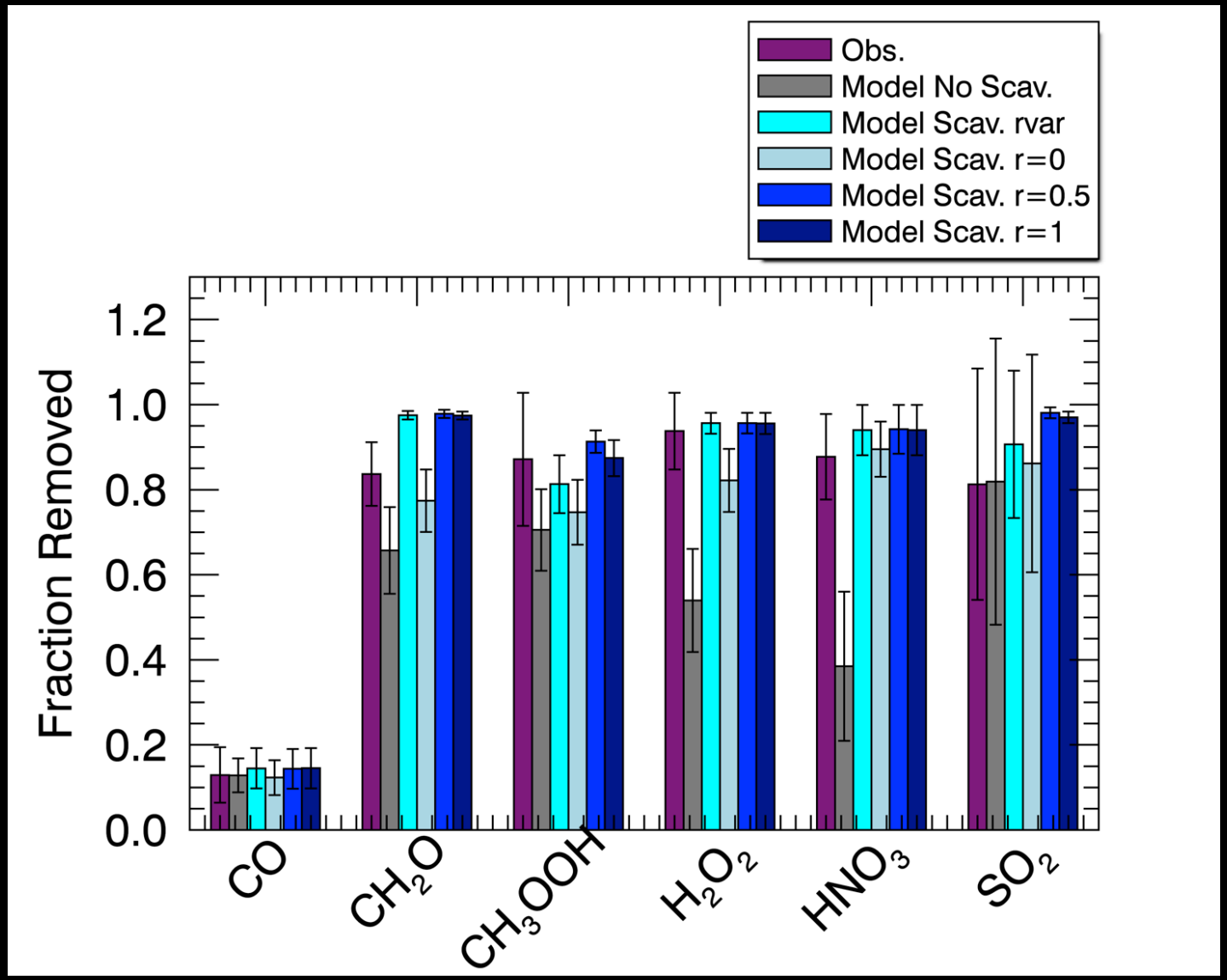

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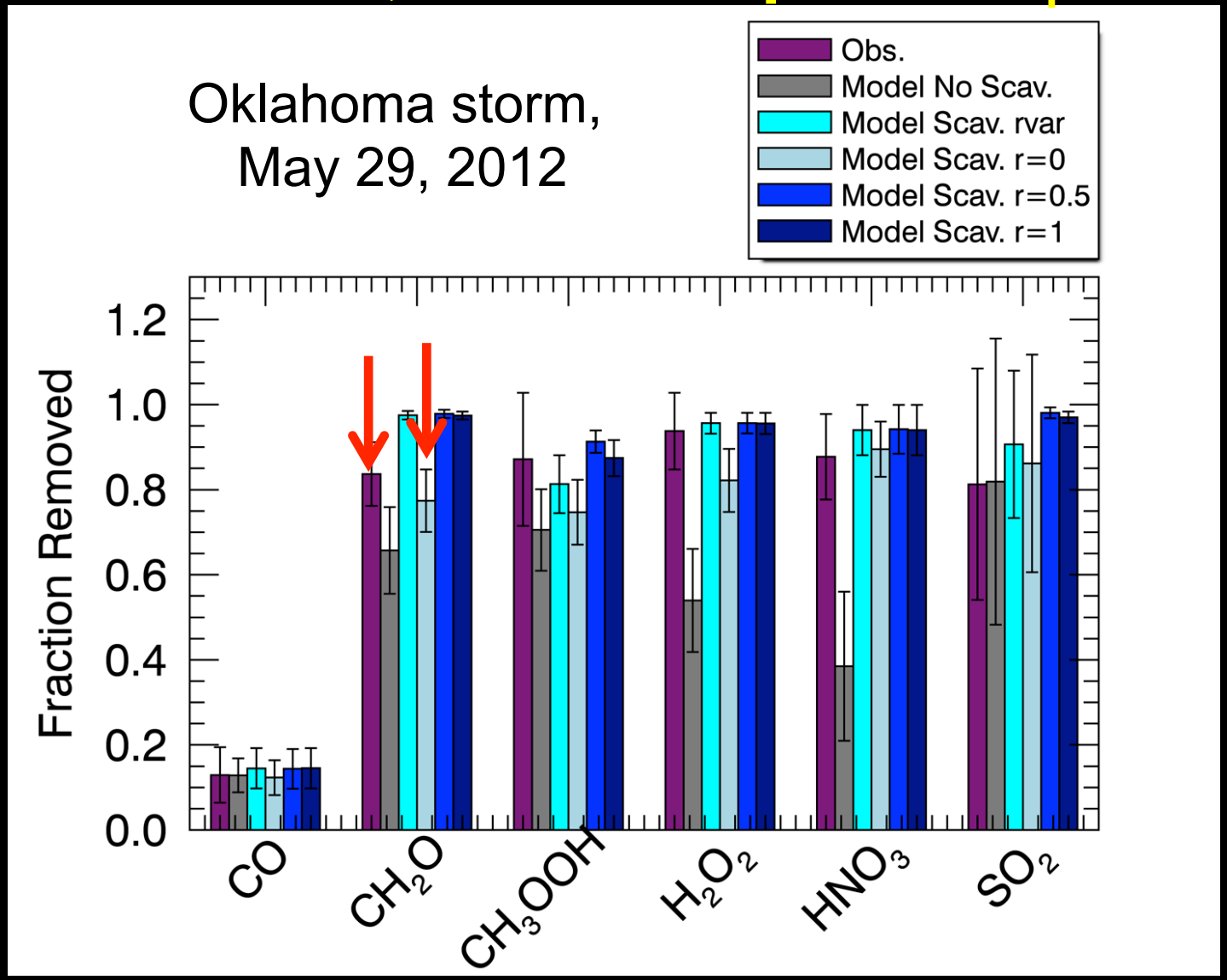
For CH_2O, r_f=0 within error bars of observations, versus expected r_f=0.64



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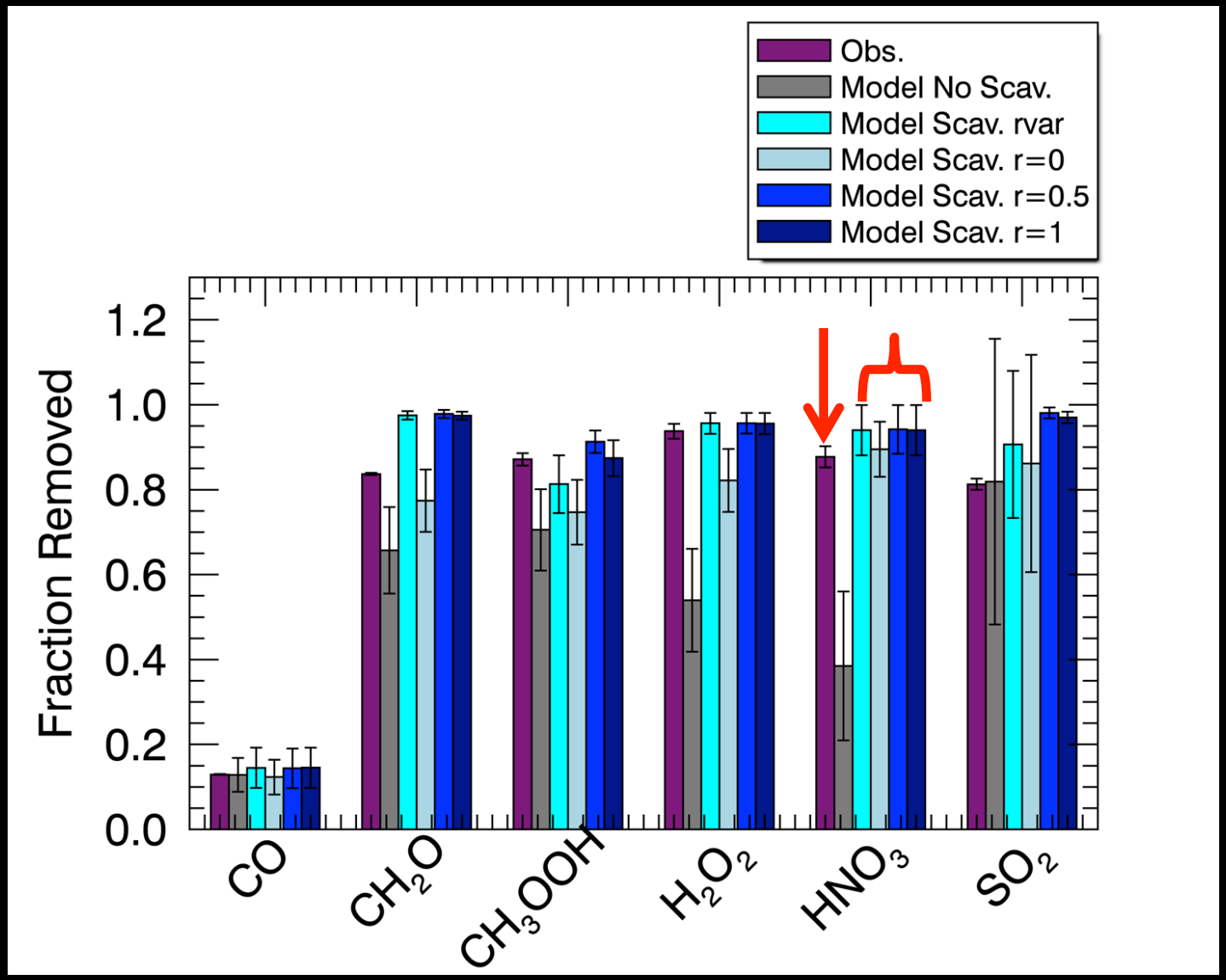
For HNO_3, r_f value has small impact on fraction removed



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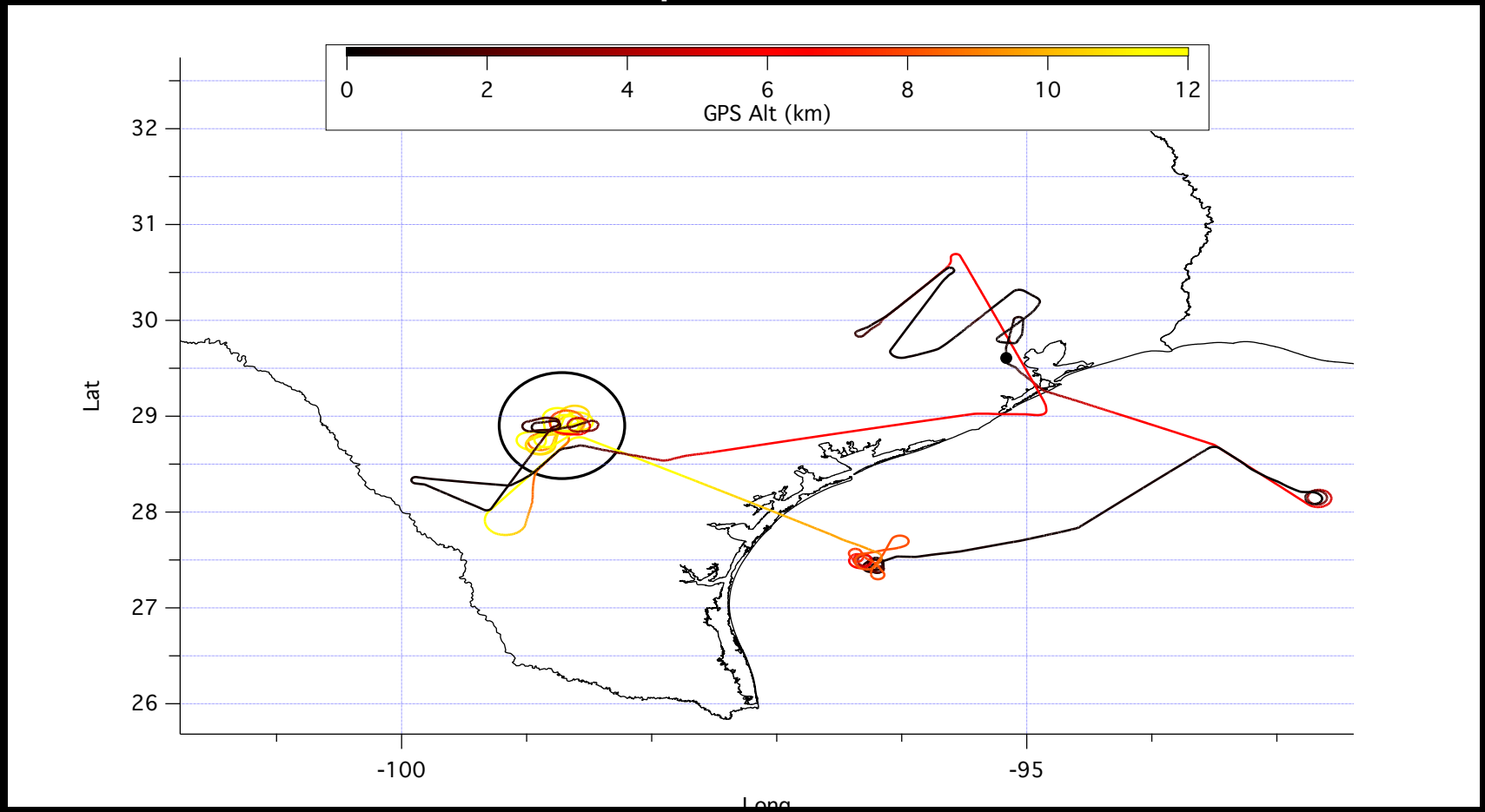
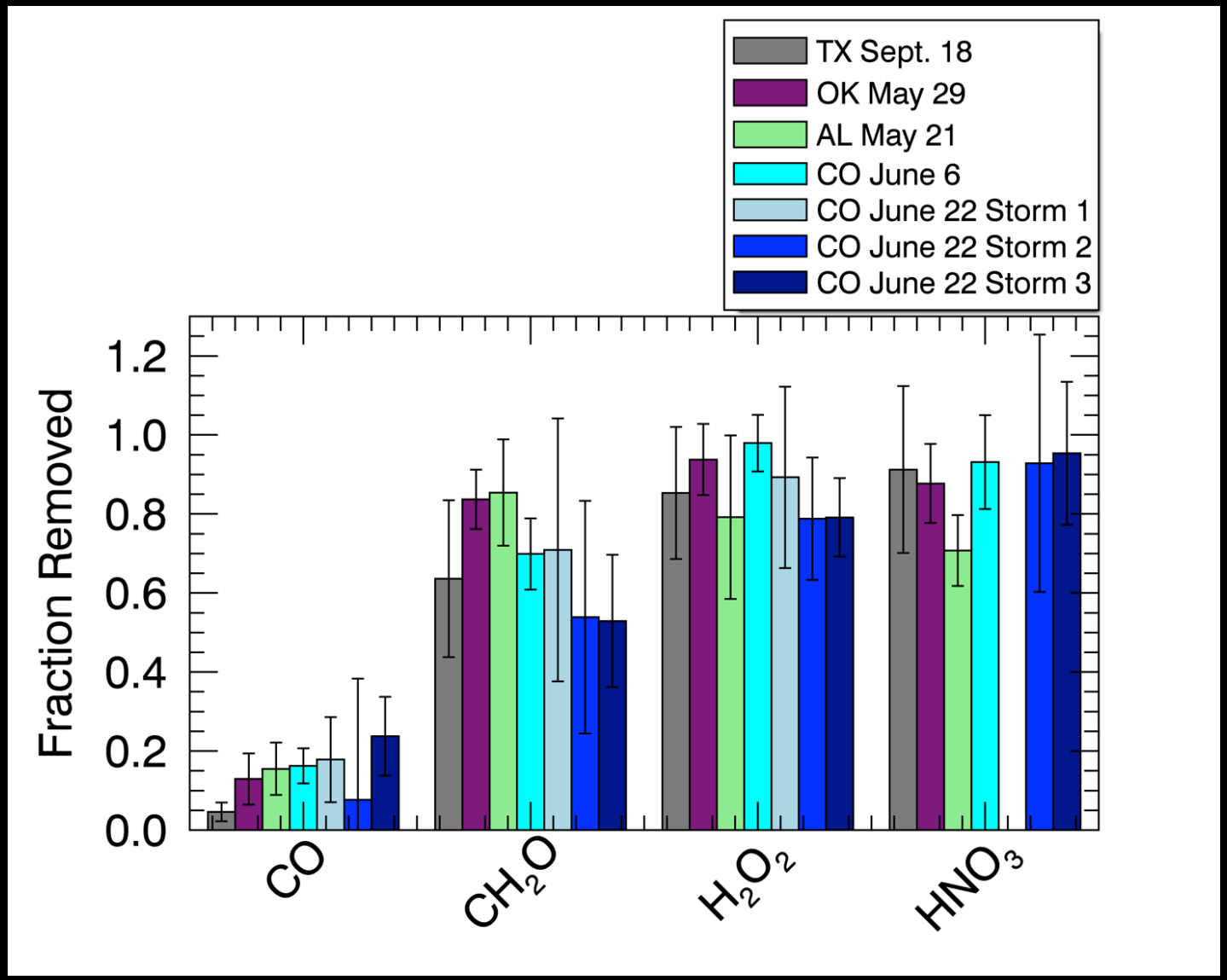
How does wet removal compare in convective core sampling from SEAC4RS?

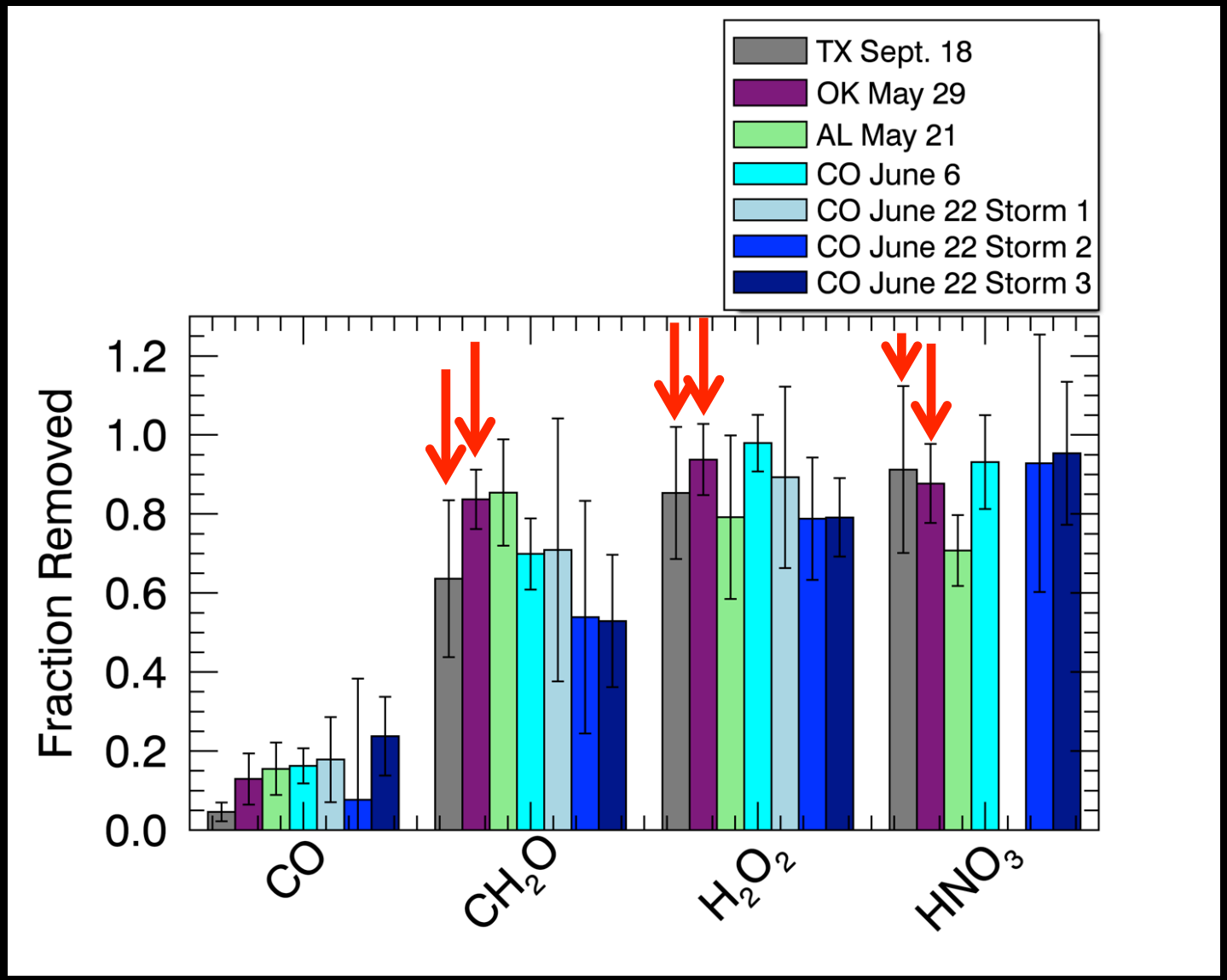
multi-cellular system, west Texas
Sept. 18, 2013



Alan Fried

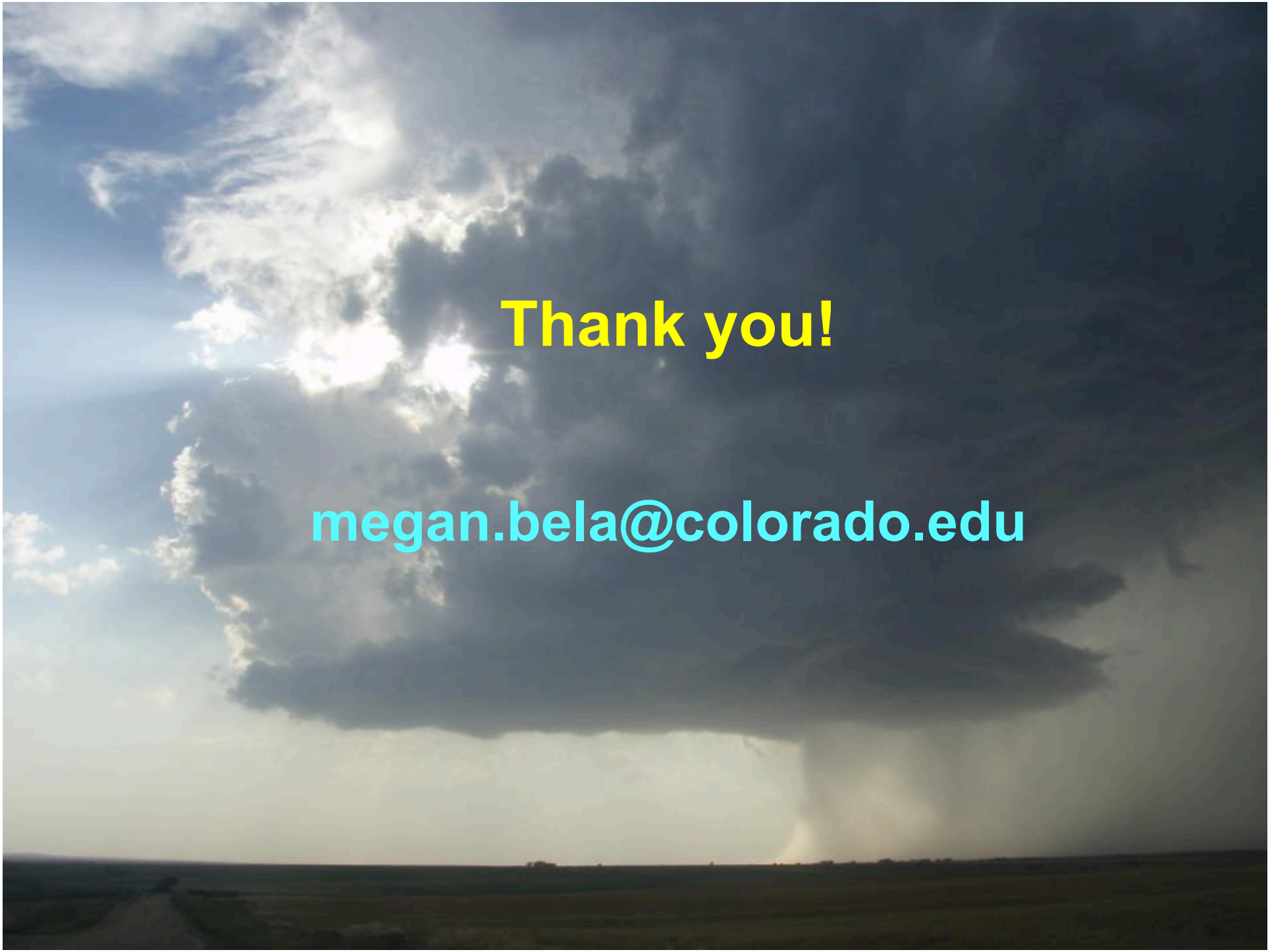

TX Sept. 18
OK May 29
AL May 21
CO June 6
CO June 22 Storm 1
CO June 22 Storm 2
CO June 22 Storm 3
Fraction Removed
0.0
0.2
0.4
0.6
0.8
1.0
1.2
CO
CH2O
H2O2
HNO3

Less removal of CH_2O and H_2O_2, more of HNO_3 in Sept. 18 than OK May 29 storms



Conclusions

- Wet removal of soluble species varies significantly among deep convective storms in different regions
- WRF-Chem represents wet removal of soluble species for a severe storm in Oklahoma
- Less removal of CH_2O and H_2O_2, more of HNO_3 in Sept. 18 than OK May 29 may be due to anvil vs. core sampling


Thank you!
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